ARTICLE 34

AMENDMENT

(Amendment under Art. 11)

To: Commissioner, Patent Office

1. Identification of the International Application

   PCT/JP03/01245

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5. Scope of Amendments

   Specification and claims

6. Contents of Amendments

(1) Claims 1, 3, and 6 through 10 are amended as on the attached sheets.

(2) Specification, page 4 lines 5 through 18 are amended from "In order to solve .... starting signal" to "In order to solve the conventional problems described above, the threading control method related to the present invention comprises a step of computing the present position of a main spindle, a step of generating a main-spindle position correction amount in order to make a single-rotation reference signal of the main spindle synchronous with a control cycle, based on the single-rotation reference signal of the main spindle and the computed present position of the main spindle, and of correcting, by this main-spindle position correction amount, the position of the main spindle so that the single-rotation reference signal of the main spindle and the control cycle are synchronized, a step of confirming the synchronization of the control cycle and the main-spindle single-rotation reference signal whose position has been corrected, and a step of outputting a command to the threading spindle when the main-spindle single-rotation reference signal and the control cycle are synchronized."

(3) Specification, page 5 lines 7 through 15 are amended from "Thus, the correction ... spindle increases." to "Thus, correction can be done below the maximum rotational frequency of the main spindle, so that thread-cut machining can be carried our safely. Further, the threading control method of this invention is such that, when the deviation between the single-rotation reference signal of the main spindle and the control cycle is below a prescribed value, and the rotational frequency of the main spindle is below a

designated value, the position of the main spindle is corrected in the direction in which the rotational frequency of the main spindle increases."

(4) Specification, page 6, line 4, through to page 8, line 9, are amended from "A numerical control apparatus ... from an arbitrary angle." to "A threading control apparatus related to the present invention comprises a main-spindle position computation means for computing the present position of a main spindle, a main-spindle position correcting means for generating a main-spindle position correction amount in order to make a single-rotation reference signal of the main spindle synchronous with a control cycle, based on the single-rotation reference signal of the main spindle and the main-spindle present position computed by the main-spindle position computation means, and for correcting, by this main-spindle position correction amount, the position of the main spindle so that the single-rotation reference signal of the main spindle and the control cycle are synchronized, a threading-spindle interpolation start detection means for confirming the synchronization of the control cycle and the main-spindle single-rotation reference signal whose position has been corrected, and an interpolation means for each spindle for outputting a command to the threading spindle when the main-spindle single-rotation reference signal and the control cycle are synchronized.

As a result it is possible, without changing the conventional H/W, to make the control cycles conform with the rotational cycle of the main spindle, by correcting the position of the main spindle from the present main-spindle position counter value and the main-spindle single-rotation reference position. In this way, even in cases where the thread-cut machining is

repeated several times while changing the tool cutting amount, since variations are not produced when starting threading and close to the end point of the threading, the thread-cut machining accuracy is improved. Since the threading end point path is constant, changes in cutting load are reduced and the tool life is extended.

Furthermore, the threading control apparatus of this invention is such that the main-spindle position correcting means corrects the position of the main spindle in a direction in which the rotational frequency of the main spindle diminishes.

Thus, correction can be done below the maximum rotational frequency of the main spindle, so that thread-cut machining can be carried our safely.

Further, the threading control apparatus of this invention is such that, when the deviation between the single-rotation reference signal of the main spindle and the control cycle is below a prescribed value, and the rotational frequency of the main spindle is below a designated value, the position of the main spindle is corrected by the main-spindle position correcting means in the direction in which the rotational frequency of the main spindle increases.

As a result, the time necessary for correction is reduced and the cycle time is shortened.

Furthermore, the threading control apparatus of this invention is such that the main-spindle position correcting means performs computation with the correction amount for the main-spindle position below the maximum correction amount, so that the main-spindle rotational variations

are within predetermined variations.

As a result, the main-spindle speed variations can be restrained and the occurrence of inaccuracies and main-spindle alarms can be restrained.

Additionally, the threading control apparatus of this invention is such that the main-spindle position correction amount, computed by the main-spindle position correcting means, includes the threading starting angle.

As a result, it is possible to start thread-cut machining from an arbitrary angle".

7. List of attached documents

(1) Claims set as amended are at pages from 17 to 20

(2)Amended specification is at pages from 4 to 8

replaced by Article 34

DISCLOSURE OF INVENTION

In the light of these types of issues, the present invention has as an object the provision of a threading control method and apparatus therefor, that can perform thread-cut machining with good accuracy, without the occurrence of variations at the start of threading, even in cases where thread-cut machining is repeated several times while altering tool cutting amount, without changing the conventional H/W.

In order to solve the conventional problems described above, the threading control method related to the present invention comprises a step of computing the present position of a main spindle, a step of generating and outputting main-spindle position correction amount in order to make a single-rotation reference signal of the main spindle synchronous with the control cycles of a threading spindle and the main spindle, based on the single-rotation reference signal of the main spindle and the computed present position of the main spindle, a step of confirming that the control cycles are synchronous with the single-rotation reference signal of the main spindle whose position is corrected by the generated and outputted main-spindle position correction amount, and of outputting an interpolation starting signal for the threading spindle, and a step of outputting a command to the threading spindle by means of the outputted interpolation starting signal.

As a result it is possible, without changing the conventional H/W, to make the control cycles conform with the rotation cycle of the main spindle by correcting the position of the main spindle, from the present

main-spindle position counter value and the main-spindle single-rotation reference position. In this way, even in cases where the thread-cut machining is repeated several times while changing the tool cutting amount, since variations are not produced when starting threading and close to the end point of the threading, the thread-cut machining accuracy is improved. Since the threading end point path is constant, changes in cutting load are reduced and the tool life is extended.

Furthermore, the threading control method of this invention is such that the position of the main spindle is corrected in a direction in which the rotational frequency of the main spindle diminishes.

Thus, the correction can be done below the highest rotational frequency of the main spindle and the thread-cut machining can be carried out safely.

Further, the threading control method of this invention is such that, when the deviation between the single-rotation reference signal of the main spindle and the control cycle of a control spindle and the main spindle is below a prescribed value, and the rotational frequency of the main spindle is below a designated value, the position of the main spindle is corrected in the direction in which the rotational frequency of the main spindle increases.

As a result, the time necessary for correction is reduced and the cycle time is shortened.

Furthermore, the threading control method of this invention is such that the main-spindle position correction amount is computed to be below the maximum correction amount of the main spindle, so that the variations

in rotation of the main spindle are within predetermined variations.

As a result, main-spindle speed variations can be restrained and the occurrence of inaccuracies and main-spindle alarms can be restrained.

Additionally, the threading control method of this invention is such that the main-spindle position correction amount includes the threading starting angle.

As a result, it is possible to start thread-cut machining from an arbitrary angle.

A numerical control apparatus related to the present invention comprises a main-spindle position computing means for computing the present position of the main spindle, a main-spindle position correcting means for generating and outputting main-spindle position correction amount in order to make a single-rotation reference signal of the main spindle synchronous with the control cycles of a threading spindle and the main spindle, based on the single-rotation reference signal of the main spindle and the present position of the main spindle computed by the main-spindle position computing means, a threading-spindle interpolation starting signal output means for confirming that the control cycles are synchronous with the single-rotation reference signal of the main spindle whose position is corrected by the main-spindle position correction amount generated and outputted by the main-spindle position correcting means, and for outputting an interpolation starting signal for the threading spindle, and an interpolation means for each spindle for outputting a command to the threading spindle by means of the outputted interpolation starting signal

from the threading-spindle interpolation starting signal output means.

As a result it is possible, without changing the conventional H/W, to make the control cycles conform with the rotational cycle of the main spindle, by correcting the position of the main spindle from the present main-spindle position counter value and the main-spindle single-rotation reference position. In this way, even in cases where the thread-cut machining is repeated several times while changing the tool cutting amount, since variations are not produced when starting threading and close to the end point of the threading, the thread-cut machining accuracy is improved. Since the threading end point path is constant, changes in cutting load are reduced and the tool life is extended.

Furthermore, the numerical control apparatus of this invention is such that the main-spindle position correcting means corrects the position of the main spindle in a direction in which the rotational frequency of the main spindle diminishes.

Thus, correction can be done below the maximum rotational frequency of the main spindle and thread-cut machining can be carried our safely.

Further, the numerical control apparatus of this invention is such that, when the deviation between the single-rotation reference signal of the main spindle and the control cycles of a control spindle and the main spindle is below a prescribed value, and the rotational frequency of the main spindle is below a designated value, the main-spindle position correcting means corrects the position of the main spindle in the direction in which the

rotational frequency of the main spindle increases.

As a result, the time necessary for correction is reduced and the cycle time is shortened.

Furthermore, the numerical control apparatus of this invention is such that the main-spindle position correcting means performs computation with the correction amount for the main-spindle position below the maximum correction amount, so that the main-spindle rotational variations are within predetermined variations.

As a result, the main-spindle speed variations can be restrained and the occurrence of inaccuracies and main-spindle alarms can be restrained.

Additionally, the numerical control apparatus of this invention is such that the main-spindle position correction amount computed by the main-spindle position correcting means includes the threading starting angle.

As a result, it is possible to start thread-cut machining from an arbitrary angle.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a block diagram illustrating one configuration example of an NC apparatus related to Embodiment 1 of the present invention;

Fig. 2 is an explanatory diagram for threading control related to Embodiment 1 of the present invention;

Fig. 3 is a diagram explaining an effect related to Embodiment 1 of the present invention;

What is claimed is:

1. A threading control method for moving a cutting tool on a threading spindle and a workpiece on a main spindle in synchronicity with rotation of the main spindle to machine thread grooves in the workpiece, the threading control method comprising:

a step of computing the present position of the main spindle;

a step of, based on the computed present position of the main spindle and on a main-spindle single-rotation reference signal, generating and outputting a main-spindle position correction in order to synchronize the main-spindle single-rotation reference signal to a control cycle for the threading spindle and the main spindle;

a step of confirming that the control cycle is synchronous with the main-spindle single-rotation reference signal having been positionally corrected by the generated and outputted main-spindle position correction, and outputting an interpolation starting signal for the threading spindle; and

a step of outputting a command to the threading spindle according to the outputted interpolation starting signal.

2. The threading control method as recited in claim 1, wherein the main-spindle position is corrected in a direction in which the main-spindle rotational frequency decreases.

3. The threading control method as recited in claim 1, wherein when the deviation between the main-spindle single-rotation reference signal and the control cycle for the threading spindle and the main spindle are below a prescribed value, and the rotational frequency of the main spindle is below a designated value, then the position of the main spindle is corrected in a direction in which the rotational frequency of the main spindle increases.

4. The threading control method as recited in claim 1, wherein the main-spindle position correction is computed to be below a main-spindle maximum correction, in order that variations in the main-spindle rotation be within a prescribed variation range.

5. The threading control method as recited in claim 1, wherein the main-spindle position correction includes a threading start angle.

6. A numerical control apparatus for moving a cutting tool on a threading spindle or a workpiece on a main spindle in synchronicity with rotation of a main spindle to machine thread grooves in the workpiece, the threading control method comprising:

a main-spindle position computing means for computing the present position of the main spindle;

a main-spindle position-correcting means for, based on the

present position of the main spindle computed through the main-spindle position computing means and on a main-spindle single-rotation reference signal, generating and outputting a main-spindle position correction in order to synchronize the main-spindle single-rotation reference signal to a control cycle for the threading spindle and the main spindle;

a threading-spindle interpolation starting signal output means for confirming that the control cycle is synchronous with the main-spindle single-rotation reference signal having been positionally corrected by the main-spindle position correction, generated and outputted by the main-spindle position-correcting means, and outputting an interpolation starting signal for the threading spindle; and

interpolation means for each spindle for outputting a command to the threading spindle according to the interpolation starting signal outputted by the threading-spindle interpolation starting signal output means.

7. The numerical control apparatus as recited in claim 6, wherein the main-spindle position-correcting means corrects the main-spindle position in a direction in which the rotational frequency of the main spindle decreases.

8. The numerical control apparatus as recited in claim 6, wherein when the deviation between the main-spindle single-rotation reference signal and the control cycle for the threading spindle and the main spindle are below a prescribed value, and the rotational frequency of the main spindle is below a designated value, then the main-spindle position-correcting means corrects the main-spindle position in a direction in which the rotational frequency of the main spindle increases.

9. The numerical control apparatus as recited in claim 6, wherein the main-spindle position-correcting means computes the main-spindle position correction to be below a maximum correction amount, in order that variations in the main-spindle rotation be within a prescribed variation range.

10. The numerical control apparatus as recited in claim 6, wherein the main-spindle position correction computed by the main-spindle position-correcting means includes a threading start angle.